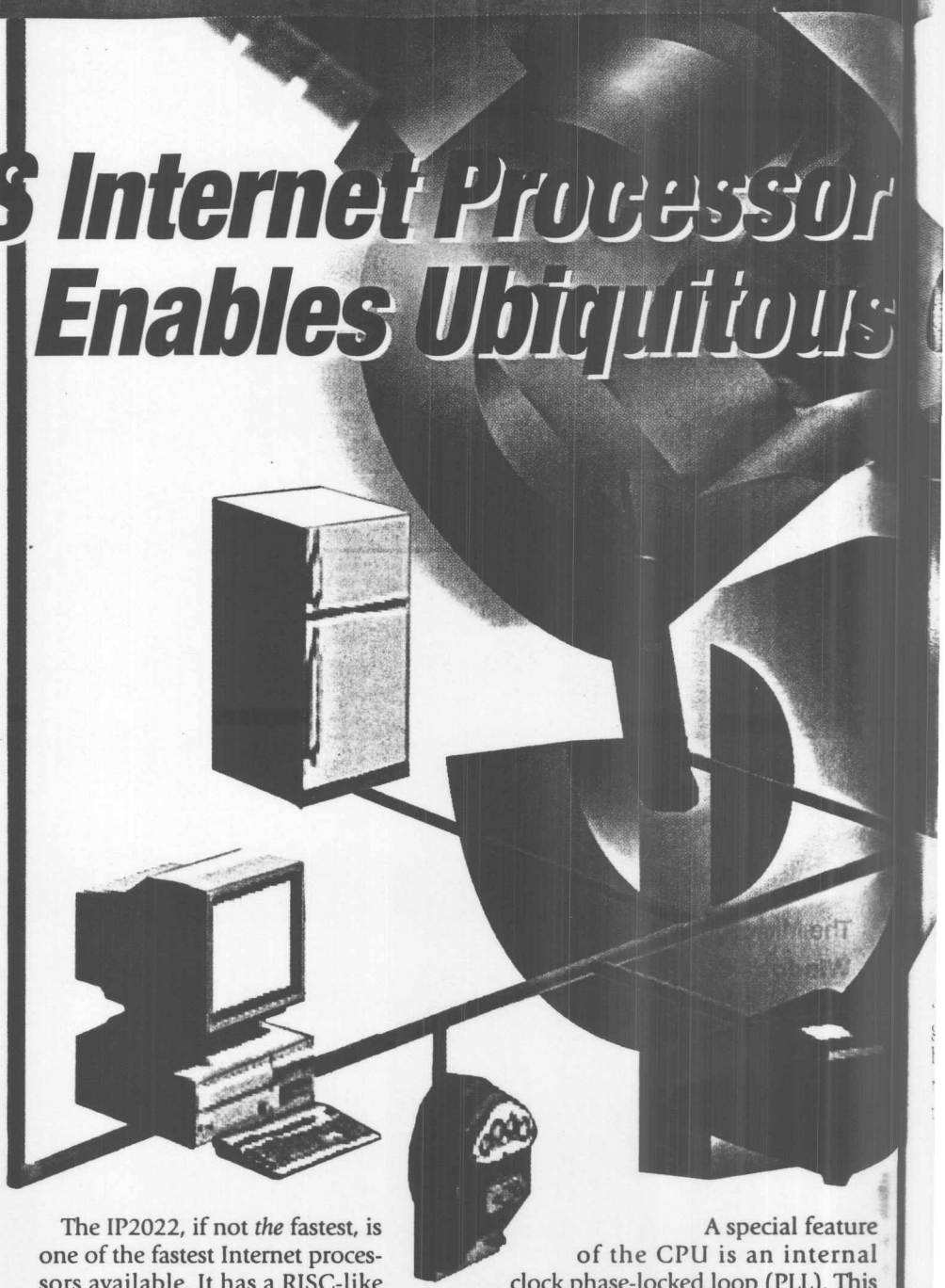
100-MIPS Internet Processor Enables Ubiquitous



When designing communications products, the time pressure to get your product to market is intense because there's only a narrow window of opportunity during which products become winners or losers. On top of that, you must be sure that the cost is low and that your design conforms to the latest of the constantly changing standards. Furthermore, the product has to be upgradable to protect it against the impossibly short life cycles that are presently the norm. In other words, it's engineering business as usual with its next-to-impossible tradeoffs. But maybe not, thanks to Ubicom's new IP2022 "killer" embedded controller.

Shortened from ubiquitous communications, Ubicom, is the new name for Scenix Semiconductor Inc. Founded in 1996, this company delivered its first products in 1998. Ubicom offers a line of high-speed embedded controllers (SX28/52) that are widely used in a variety of telecommunications and other applications. The company's claim to fame has been its Virtual Peripheral Modules (VPMs). These prewritten software routines implement common control and interface functions, and are stored in the controller's EEPROM/flash memory.

Ubicom's objective is to make the processor's performance high enough that users can implement hardware functions in software, thereby eliminating the need for more expensive ASICs, FPGAs, or other hardware solutions. The IP2022 is the next step in this concept, but with an increased focus on embedded Internet applications. To emphasize this focus, the communications-centric software modules that will be used with the IP2022 and future products are called "ipModules."

The IP2022, if not *the* fastest, is one of the fastest Internet processors available. It has a RISC-like modified Harvard architecture that runs at clock speeds up to 100 MHz. *(Fig. 1)*. The 8-bit CPU has all of the usual instructions, including both signed and unsigned 8- by 8-multiply instructions.

Separate program and data memories permit simultaneous instruction and data accesses as well as pipelined operations with fetch, decode, execute, and write-back phases, resulting in one instruction execution per cycle. Because most instructions are a single word (except for branches that take three cycles), one instruction executes per cycle giving a performance approaching 100 MIPS. That's pretty hot for a nonDSP embedded controller.

A special feature of the CPU is an internal clock phase-locked loop (PLL). This circuit is used as a fixed 50-times frequency multiplier to boost the frequency of an external crystal. As a result 100-MHz clock is obtained from a 2-MHz crystal. The use of the lower-frequency crystal reduces EMI.

The PLL also contains programmable post-divide and predivide circuitry so that the clock frequency can be selected through software. For example, speed can be reduced under program control to minimize power consumption. Execution speed can be balanced with power consumption to optimize any given application.

The on-chip program memory consists of a 32-kword by 16-bit flash plus an 8-kword by 16-bit shadow SRAM.

An inexpensive, embedded, and reconfigurable device accelerates the development of communications applications.

Communications

Louis E. Frenzel
COMMUNICATIONS/NETWORKING

The flash is in-system programmable through a serial peripheral interface (SPI) input. The programming voltage is a typical supply voltage of 2.5 V. No separate external programmer is needed to initially load the software or update it later as required.

The data SRAM has a capacity of 4 kwords by 8 bits and is configured as 128 special-purpose registers, 128 general-purpose registers, and 3840 bytes of generic storage space. All 256 memory registers are addressable via the instructions.

Voltage requirements for the chip are 2.3 to 2.7 V, with 2.5 V typical and 4.5 V maximum for both digital and analog circuits. I/O pin voltages may be as high as 5.7 V. Separate analog and digital power and ground pins are provided to minimize noise. Power consumption is obviously dependent on clock speed.

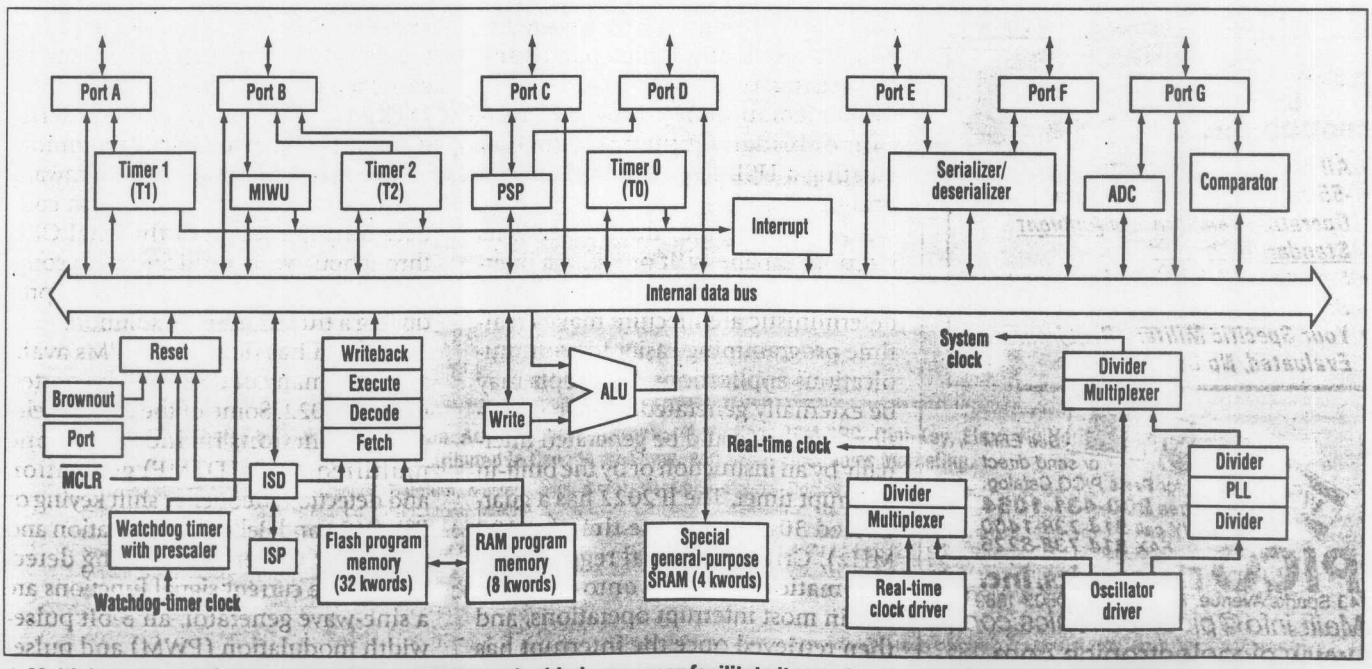
The IP2022 is available in a 14- by 20-mm PQFP 80-pin package with a 0.8-mm pin pitch.

Communications-Optimized I/O

The I/O on the IP2022 was optimized for communications applications. It has a total of 52 I/O pins divided as seven ports designated A through G. The I/O pins can be designated as inputs or outputs as necessary. The inputs are CMOS compatible. Output pins don't require external pull-up resistors, nor are they permitted. The 4-bit port A is used for high-power outputs as it can source or sink 24 mA. This allows it to drive low-power peripheral devices, like a speaker or a relay. Timer 1 also uses these pins for I/O. Ports B through G are 8 bits each and sink or source 4 or 8 mA. Port B can be set up to accept as many as eight separate interrupts.

Additionally, Port G is used for the 8-input analog multiplexer associated with the internal analog-to-digital converter (ADC). The ADC produces a 10-bit (1/2 LSB accuracy) output. The maximum sampling rate is 48 kHz. An external reference voltage may be used as an alternative to the internal 2.5-V reference. Plus, an analog comparator is available for other analog operations. It has a 15-MHz bandwidth and a 100-mV peak-to-peak minimum input. The hysteresis is selectable.

Also included in the I/O section are the following: two 16-bit timers with extended prescalers that can be used for generic timing operations, PWM, or



1. Multiple ports and timers on the Ubicom IP2022 embedded processor facilitate its use for low-cost Internet connectivity.

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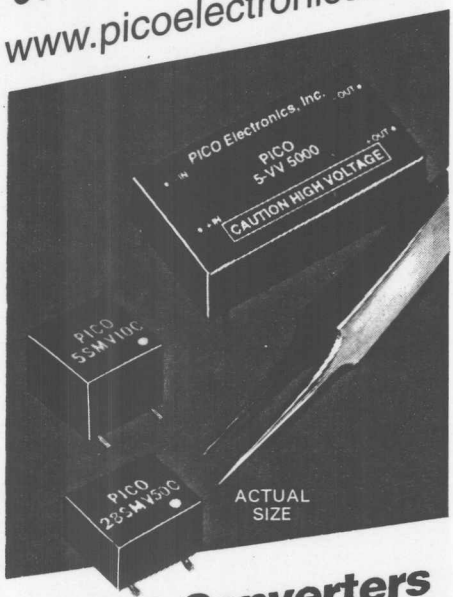

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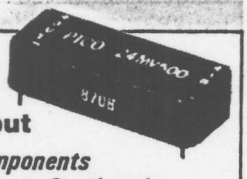

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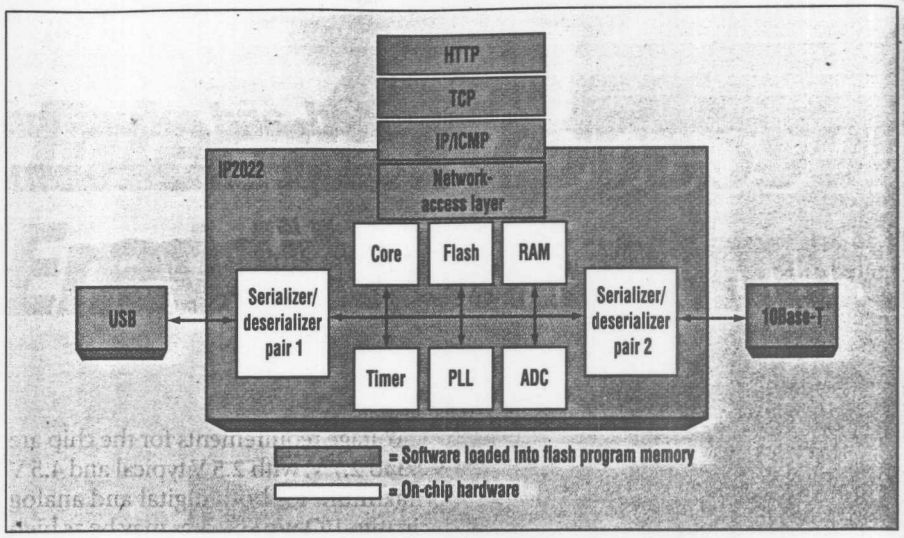


2. With only an inexpensive external USB transceiver and a few analog components for the Ethernet interface, the IP2022 can be used as a true high-end single-chip protocol converter.

capture-compare operations; an 8-bit real-time timer with a programmable 16-bit prescaler; an 8-bit real-time clock counter/timer with a programmable 8-bit prescaler; and a watchdog timer with a prescaler.

Ports E and F have serializer/deserializer capability. Two pairs of 16-bit serial/parallel I/Os minimize the need for external circuitry. This is a critical feature in communications and networking applications.

The serializer/deserializer (SerDes) units support a variety of protocols, including 10Base-T Ethernet, USB, SPI, and I^2C. By performing data serialization/deserialization in hardware, the CPU bandwidth needed to support serial communications is greatly reduced, especially at high band rates. Providing two units allows easy implementation of protocol conversion or bridging functions, such as creating a USB-to-10Base-T Ethernet bridge. *(Fig. 2)*.

A key highlight of the IP2022 is its interrupt capability. It provides a jitter-free response in three clock cycles. This deterministic architecture makes real-time programming easier for communications applications. Interrupts may be externally generated voltage transitions, or they could be generated internally by an instruction or by the built-in interrupt timer. The IP2022 has a guaranteed 30-ns response time (at 100 MHz). Critical internal registers are automatically pushed onto the stack like in most interrupt operations, and then retrieved once the interrupt has been serviced.

What makes the IP2022 so attractive are Ubicom's ipModules, which are blocks of ready-to-run code written by Ubicom or a third party and available for free from the company's Web site. They implement many of the most popular I/O and interface functions often needed in communications and networking equipment. They can be used as interrupt routines, program subroutines, or as a part of the main program. Further, ipModules are similar to the VPMs available for the SX28/52 processors.

The most powerful way to employ an ipModule is as an interrupt routine because it can function transparently in the background of the main program. Furthermore, the ipModules are independent of one another, so they can be easily removed or added as needed.

The Ubicom objective is to write tight, fast code that emulates commonly required communications hardware. With an ultra-fast processor, such code uses only a fraction of the total CPU throughput, while reducing, or in some cases eliminating, external ICs and producing a true single-chip solution.

Ubicom has dozens of VPMs available and many of these will be ported to the IP2022. Some of the current telephony functions include dual-tone multifrequency (DTMF) generation and detection, frequency shift keying or FSK (V.23 and Bell-202) generation and detection, Caller-ID, and ring detection. Some current signal functions are a sine-wave generator, an 8-bit pulse-width modulation (PWM) and pulse-frequency modulation (PFM) digital-

to-analog converter (DAC), and an 8-bit sigma-delta ADC.

Typical interface VPMs are I^2C master and slave, Microwire, a serial-parallel interface (SPI) master and slave for both high- and low-speed applications, an IrDA stack, and a variety of RS-232 and UART programs. You can also acquire several LCD interfaces, a 4- by 4-keyboard scanner, and discrete Fourier transform (DFT) or fast Fourier transform (FFT) packages. A variety of basic math functions are on hand too, so that you don't have to write them.

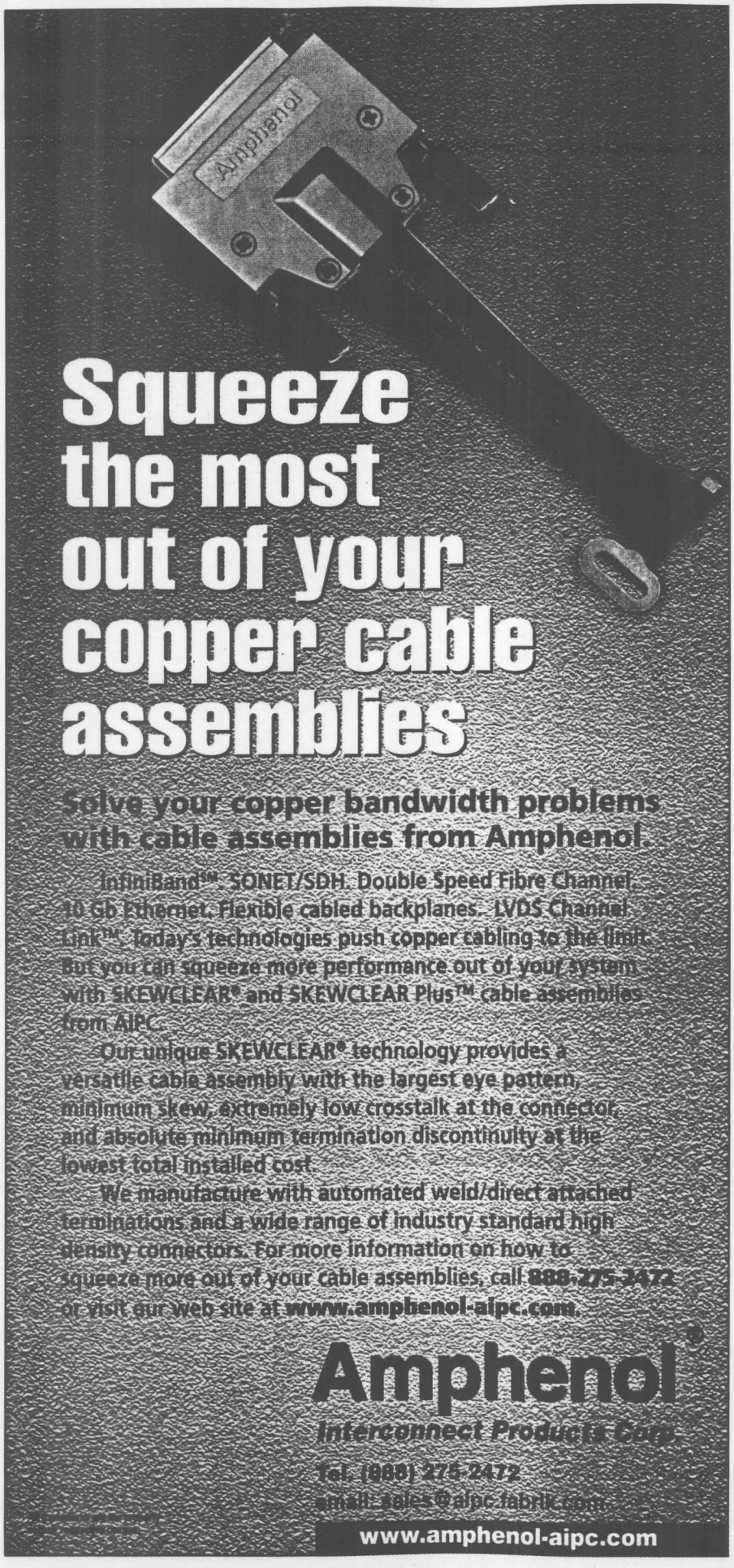
The ipModules available for the IP2022 help implement more advanced communications functions, including Internet access. For instance, there are the 12-MHz USB and 10Base-T Ethernet packet-processing software modules. Plus, for Internet access, such protocols as TCP/IP, UDP, HTTP, SMTP, PPP, and POP3 are available. Modules to handle the following network stack-processing tasks are on-hand for engineers to use: UDP/IP/PPP, HTTP/TCP/IP/PPP, and HTTP/TCP/IP/PPP. Designers can look forward to more modules for Bluetooth and Home Phone Networking Alliance (HPNA) protocols, as well as others.

Standards Speed Design

The beauty in all of this is that most procedures and protocols are standards and are already programmed for users. This cuts design time and debug hassle to a minimum, letting them put together a product in record time. Obviously, they will need to develop some software on their own, but Ubicom has provided for that as well.

The IP2022 is supported by third-party software tool developers. Cygnus/Red Hat supplies an editor, C compiler, assembler, linker, utilities, and the GNU debugger. All of this matches up with the on-chip in-system debug capabilities built into the embedded controller. Hardware support exists for unlimited breakpoints, single-step, run, and stop logic. Users can actually test and revise the code inside of the device while it's running the application. Other development software includes the Nohau High-End Debugger with a See-hau interface, USB debug hardware, and an assembler.

Ubicom's principle focus with the IP2022 may involve commercial or industrial LANs, wide-area networks, or residential networks, but the working term is Internet-connected. Today,



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most of these connections are person-to-person. On the horizon is the potential for device-to-person and vice versa, as well as device-to-device communications. Virtually all of these types of communications will be embedded in the device whether it's a machine tool, appliance, or simply a remote sensor. The Internet becomes the communications "cloud" that can connect anything to anything else.

Many are predicting huge growth in the embedded Internet market. When that happens, it will change the way that we work, play, and even think about things. There are many applications possibilities. Consider, for instance, some industrial applications which might encompass monitoring the status of a machine tool or making measurements with sensors at a remote site.

Any kind of data acquisition is a good example because the data collected could be posted on a small Web page accessed via the Internet for informational purposes or for use in remote computing. The control of a device or system from some remote location is also easily done this way.

Smart highways are another possibility. Remote monitoring and control could be done like that. Sensor data, or even video indicating the state of traffic or weather conditions, could easily be monitored. Warning signs or traffic signals could be activated, too, in response to specific conditions.

Perhaps the ultimate application would be in the home. We're just beginning to see networked PCs at home. The availability of home gateways permits two or more PCs to have Internet access. What else can be networked? Your security system is a real possibility, as is the heating and air-conditioning system.

A lot of people claim that most appliances are targets of opportunity. While a major appliance like a refrigerator or washing machine may be a candidate for networking, it's doubtful that we will see toasters, hair dryers, or blenders operating in a networked mode.

Home entertainment devices might also be networked. TV sets, VCRs, DVDs, audio systems with MP3 capability, and games are all ripe for some kind of Internet access. Of course, monitoring and controlling utilities, such as electric, gas, or oil, is a real possibility. The IP2022 can be used in all of these applications.

Some examples are a simple one-page Web server inside of a hot-water heater, or a simple e-mail server inside of a security system. You get the idea. In any case, all of these devices require "super cheap" hardware to make them practical and affordable. The IP2022 is a device that has the necessary performance at this consumer price point.

Price & Availability

Samples of the IP2022 will be available in the first quarter of 2001. Volume production will follow in the second quarter of 2001. Unit pricing will be $9.75 each in 10,000-piece quantities.

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